The Physical and Geochemical Investigation of Effurun River Sand at Ugbolokposo and Ugbomro, Uvwie-Aladja, western Niger Delta, Nigeria

Napoleon Wessey
Department of Geology
Niger Delta University,
Wilberforce Island. Nigeria
Email: napwessey [AT] yahoo.com

ABSTRACT---- ***Fifteen samples of Effurun River sand at Ugbolokposo and Ugbomro were subjected to physical and geochemical investigation. Generally, the sand physically characterized by bright colours of white, brown and yellow. Some samples contained dark specks of organic matter. The physical grade size distribution is 1.00mm (1.40%), 0.600mm (3.40%, 0.500mm (3.80%), 0.300mm (29.60%0), 0.180mm (34.80%), 0.150mm (12.00%), 0.106mm (11.00%) and <0.106 (3.20%), sharp angular to sub-angular in shape and rounded, poorly sorted and the mean moisture content is (3.5%). From the distribution, the sand is generally of medium grade size. Geochemically by X-ray fluorescence analysis, the oxide content is SiO_2 (97.80%), CaO (0.14%), Al_2O_3 (1.17%), Fe_2O_3 (0.05%), TiO_2 (0.05%), Na_2O (0.06%), K_2O (0.45%), and L.O.I (0.25%). The physical and geochemical properties results indicate that the sand is a good material for direct use in coloured glass making, and in the building and construction industries. On beneficiation or processing, the sand can be used for general colourless glassware manufacture.***

Keywords--- Effurun River sand, physical and geochemical properties, industry

1. INTRODUCTION

Sand is a sedimentary material ranging in size from 2.00mm to $^1/_{16}$mm (0.0625mm), finer than gravel and coarser than silt and clay. It consists of small grains or particles of mineral and rock fragments. Sand grains as classified may be produced naturally from rocks (igneous, sedimentary and metamorphic) by mechanical, chemical and biological processes (Udden, 1922; WentWorth, 1922; PettiJohn, 1957; Tucker, 1981; Collins and Fox, 1985. The grains may be of any mineral composition but the dominant component of natural sand is the mineral quartz, which is composed of silica (silicon dioxide- SiO_2). Sand with particularly high silica levels that is used for glassmaking and not for construction purposes is referred to as silica sand or industrial sand produced from unconsolidated sands and crushed sandstone rocks. The other mineral components of sands are feldspar, chromium, titanium, magnetite, and the carbonates. Sand can also be derived from other artificial or synthetic rocks such as slag, by crushing and used as fine aggregates. Sand derived from synthetic rocks has a mineral composition similar to that of cement clinkers composed majorly of silicate minerals like alite and belite; and the iron rich ferrites (Gutt, 1972; Gutt and Nurse, 1974; Wessey, 1988). Sand has found uses as aggregates in the construction, building and transport industries, foundries, glassmaking, ceramics, water filtration, fluidized-bed furnaces, chemical manufacture, plastics, abrasives, cement and blasting industries based on either chemical purity or physical properties (Knill, 1978; Collins and Fox, 1985; BS 2975: 1988). Sand in the Niger Delta of Nigeria, abundantly occurring along river or stream beds, on beaches and on land at shallow depths are, uninvestigated before use mostly in bulk rock form in the building and construction industries resulting sometimes in structural failure. In Nigeria, there is a continuing need of sand for the production of different types of glass, sanitaryware, construction and other industrial products which are in increasing demand. These should be readily made available at affordable cost to Nigerians with abundant availability of suitable sand (Hadamach, 1991). This work therefore investigated the physical and geochemical properties of the Effurun River sand at Ugbolokposo and Ugbomro, the study area, in order to deduce its potentials for use in the glassmaking, building, construction and allied industries.

2. THE STUDIED AREA

The study area comprising of Ugbolokposo and Ugbomro western Niger Delta, falls within the Niger Delta Region and the geology is similar to that of the Region. The area located at latitude 5^0 32^1 N and longitude 5^0 45^1 E of the Greenwich meridian has a flat terraine. It is accessible directly by road off the East West Road and water through the Effurun River, a distributary of the Warri River. The Effurun River, flows by Enerhen, Afieke, Alegbo, Ugbolokposo and Ugbomro villages in the area. The area is in the Tropics and experiences a high humidity which is lessened by an accompanying increasingly marked short dry season. A longer rainy season occurs from the months of April to October

with an average rainfall of about 2665mm, heaviest in the month of July and sometimes in September. The break in rainfall in August is regarded as the August break. The dry season from about November to March, is characterized by a good amount of sunshine, with a mean daily temperatures of 30^0C and maximum temperature of about 40^0C. A cold spell particularly during December to January, called the Harmattan coincides with the dry season. The area is characterized by its freshwater tropical rain forest vegetation rich in African mango trees, raffia palm and floating plant species such as vossia cuspidala and nymphea. Mangrove trees are found in saline mangrove swamps and along the banks of Effurun River and rivulets draining the area. Sand has escaped from the Effurun River channel and finds its way into back swamps during the floods in some areas. Geologically, the sand in the study area is of Quaternary deposits of Eocene to Recent age overlying the Benin Formation (Allen, 1965; Burke and Durotoye, 1970b.; Tse and Akpokodje, 2010). Sand in the study area is never exhausted as it is being always brought and deposited annually, by the high volume rivers and streams during the flood from September to early few days of November. The thickness and volume of sand available in the streams cannot be exactly quoted but can be estimated to be trillions of tons.

3. MATERIALS AND METHOD

Field and laboratory methods were used for this study complementarily, generally in accordance with the British Standard Institute (BS 2975: 1988) specifications.

3.1. Field method

Sampling: Fifteen disturbed sand samples from sand dumps in the study area that had been dredged from the Effunrun River bed and from the sides of the River were collected. One kilogram (1kg) each of fifteen spot samples, (eight from Ugbolokposo (labeled A-H) and seven from Ugbomro (labled I-O) were carefully collected with a shovel and a trowel into polythene sample bags after the macroscopic observations (colour, texture, hand feel and eye sizing) had been made. The quartering method of disturbed sample collection was used in order to get representative samples. The sample bags were taped and labeled accordingly and taken for laboratory analysis.

3.2.Laboratory analysis

The laboratory analyses in accordance with British Standard (BS 2975: 1958/1988) and Glass Making Raw Materials, Sand, Reference:48/340, 1974 standard specifications for the Glass Manufacturers' Association, included physical determination of moisture content, and grade size analysis (sieve analysis- using sieves in agreement with British Standard (BS 410), and Geochemical analysis using the X-ray Fluorescence spectrometry (XRF) analysis method.

Test samples were left to drain in the laboratory for twenty four hours (24 hrs) after collection, and each sample was thoroughly mixed, coned and quartered again (coning and quartering) till a suitable representative sample was obtained. 150 grams of each sample was oven dried at 110^0C for 24 hrs, left in a dessicator to cool for twenty four hours (24 hrs) and weighed again for moisture content determination. Fifty (50) grams of each of the samples so treated was sieved through 2.00mm, 1.00, 0.600mm, 0.500mm, 0.180mm, 0.150mm, 0.160mm and <0.106mm) sieves available for grain size distribution analysis. After the sieving exercise, percentage retention on each sieve was calculated for each sample. The mean value for the fifteen samples were also obtained.

4. RESULTS AND DISCUSSION

The results of the physical analysis of the sand are shown in Table 1(Moisture content); Table 2 (Grain size distribution) and Table 3 (Geochemical analysis).

4.1. *Colour, texture and shape*

From the field macroscopic observation of the sand, the colour is characterized by white, brown and yellow with specks of organic matter in some places. The sand is medium sized and the grains are majorly sub-angular and rounded. Based on colour and texture the sand is suitable for use in the coloured glassmaking, building and construction industries.

4.2.*Moisture content*

The analysis results of the moisture content of selected samples and that of the mean for the fifteen samples of Effurun River sand are presented in Table 1.

Table 1. The analysis result of the moisture content of seleceted samples and that of the mean for the Effurun River sand at Ugbolokposo and Ugbomro in per centage (%)

Sample No	**Moisture content (%)**
A	4.1
B	4.7
C	6.3
D	0.6
E	1.0
F	4.4
G	2.7
H	3.3
I	1.4
J	1.1
K	2.8
Mean	2.95

From Table 1, the moisture content results of selected samples range between 0.6 per cent (%) (minimum) and 6.3 per cent (%) (maximum) and a mean value of 2.95 per cent (%). Except for Sample C with a moisture content of 6.3 per cent all other samples values fall within sand standard industrial use specifications, particularly glassmaking values. The mean value of 2.9 indicates that the 6.3 isolated value, is overshadowed by the general result and would not have an adverse effect on application of the sand for glassmaking. The sand is therefore suitable for use particularly in the building, construction and glassmaking industries based on moisture content (BS 2975: v 1988, Glass Making Raw Materials: Sand. Reference:48/340, 1974).

4.3. *Grade size distribution*

The analysis results of the grade size distribution of selected samples and that of the mean for fifteen samples are presented in Table 2.

Table 2. Grade size analysis of selected samples of Effurun River sand at Ugbolokposo and Ugbomro and that of the mean of 15 samples.

Sieve size	SAMPLES Weight retained %								
	A	C	D	F	H	I	K	L	Mean of 15 samples
1.00 mm	1.40	3.60	6.00	4.00	13.20	12.00	6.20	7.40	1.40
0.600µm	3.40	3.40	7.80	6.20	13.40	12.00	8.00	7.70	3.60
0.500µm	3.80	2.20	5.80	4.20	7.80	7.40	5.80	4.20	3.80
0.300µm	29.60	13.60	36.20	28.60	36.60	29.40	29.80	27.80	29.60
0.180µm	34.80	24.00	31.00	29.60	25.20	28.00	38.20	37.80	34.80
0.150µm	12.00	14.00	6.40	11.00	2.20	4.60	7.00	6.80	12.00
0.106µm	11.00	26.80	4.60	11.40	0.80	4.20	4.00	4.00	11.00
<0.106µm	3.20	12.40	1.60	4.40	0.40	1.20	0.08	1.20	3.20
Total	99.20	100.00	99.40	99.40	99.60	98.80	99.80	96.20	99.20

*Field Samples : (Ugbolokposo (1, 3, 4, 6, 8) and Ugbomro (9, 11, 12))

From the grain size analyses results (Table 2), the sand composition as distributed in the sieve sizes as classified here is very coarse (1.00mm- (1.40%)), coarse (0.600µm-0.500µm (7.4%)), medium (0.300µm-180µm-0.150µm (76.40%)), fine (0.106µm (11.00%)) and very fine (< 106µm (3.20%). The sand is poorly sorted and generally of medium grade size like other Niger Delta River channels, streams and estuarine recent sands of the Benin Formation (Reyment, (1965), Reijers, (1996). The poor sorting makes the sand suitable for glass manufacture (Egirani and Obande, 2003). The Effurun River sand cannot give a batch scum or burnout during glass production allowing for the production of unit glass per unit weight and an even mixture of materials consequently producing an even texture glass (Leibe, (1999), Thompson, 1989).The sand is thus suitable for glassmaking. The medium grade size of the sand, the sub-angular to rounded shape make it less energy consuming during sintering and therefore suitable for glass manufacture.

The poor sorting and sub-angularity of the sand makes it useful for landfill (land reclamation, road basses), building (as fill, concrete, plaster and block making), masonry mortars, renders and screeds, and construction purposes particularly with the sub-angular property which can give it a better binding with cement and asphalt mix in road construction (BS 2975: 1988). The fines can fill void spaces in the mix when the sand is used in concrete mixes and mortar. The sand can reduce shrinkage and cracks in brick manufacture when added to clay and mixed in foundries as molding and parting sand. The very fine fraction of the sand (<0.106µm) which might contain some expansive clay minerals such as montmorillonite could create swell and fracture problems when used in building, concrete and construction purposes (Okeke and Okogbue, 2010). Screening the very fine grade out of the sand and further washing could take care of such possible problems.

5. GEOCHEMISTRY

The geochemical analysis result (elemental oxide composition) of selected samples of the Effurun River sand at Ugbolokposo and Ugbomro and that of the mean of fifteen (15) samples by X-ray Fluorescence spectroscopy (XRF) in per centage (%) are presented in Table 3.

Table 3. Geochemical analysis result (elemental oxide composition) of selected samples and that of the mean for fifteen (15) samples of the Effurun River at Ugbolokposo and Ugbomro.

Elemental Oxide	Weight (Per cent) SAMPLES								
	A	C	D	F	H	I	K	L	Mean
SiO_2	97.81	97.80	97.81	97.79	97.80	97.81	97.80	97.80	97.80
CaO	0.14	0.14	0.15	0.15	0.14	0.14	0.14	0.14	0.14
MgO	-	-	-	-	-	-	-	-	-
Al_2O_3	1.17	1.16	1.17	1.17	1.17	1.18	1.17	1.17	1.17
Fe_2O_3	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
TiO_2	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Na_2O	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06
K_2O	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45
L.O.I	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Total	99.97	99.96	99.99	99.97	99.97	99.98	99.97	99.97	99.97

*Samples A,C,D,F,H are from Ugbolokposo and samples I,K and L from Ugbomro.

From Table 3, the mean composition results of the sand show, SiO_2 (97.80%), CaO (0.14%), Al_2O_3 (1.17%), Fe_2O_3 (0.05%), TiO_2 (0.05%), Na_2O (0.06%), K_2O (0.45%), and L.O.I (0.25%). The rounded up figures produce very similar results in all the sand samples of the study area as represented by the mean result. This is representative of the overall results as each sample analysis result seen from the SiO_2 does not vary more than the maximum mean of +- 0.20% for glassmaking. The results show an observed linear relationship between the chemical estimates of the sand as shown in the results of SiO_2 (97.80%) and Al_2O_3 (1.17%), which are the highest composition constituents of the sand and the higher concentration percentages of silica and alumina indicate the preponderance of aluminosilicates, anhydrous aluminosilicates and silicate minerals. The greater percentage of SiO_2 indicates the greater presence of other silicates, and heavy mineral assemblages (Egirani and Obande, 2003).The 97.80% content of the SiO_2, confirms the sand to be Silica or quartz sand suitable for coloured glass manufacture. The Fe_2O_3 (0.05%), TiO_2 (0.05%), Al_2O_3 (1.17%) and L. O. I. (2.95%) can limit the sand for use in general brown and green glass making. Fe_2O_3 and TiO_2 are colouring agents in the sand that can taint glass.

The test results values when compared to the minimum standard values of SiO_2 (98.8%), maximum value for Fe_20_3 (0.03%) in particular, are too low for use in colourless glass making (Glass Making Raw Materials, Reference 48/340, 1974; BS 2975: 1988). However, the sand can be processed to reduce the content of other colouring elemental oxides particularly, Fe_2O_3 to about 0.03% maximum from 0.05%, TiO_2, and Al_2O_3, by the use of decolouring agents such as metallic gold, selenium, cobalt, niobium and manganese during glassmaking process. This can increase the SiO_2 content to between 98.8- 99.7% suitable for the manufacture of colourless container glass, tableware, crystal glass, optical and ophthalmic glasses to meet the glass manufacturers specifications (Wessey, 1984). The alumina content of 1.17% in the sand is much lower than the 4% specification for the making of common glass and cannot be harmful in common glass (Slack, 1987).On the basis of alumina content, the Effurun River sand is suitable for common glassmaking because the 1.17% present cannot cause devitrification but not for optical glass manufacture which requires less than 0.1% alumina (Slack, 1987).

The silica content (97.80%) of the sand is well above the industrial specification of 80% for sanitaryware making and suitable for the silica brick industry, for road dressing mixed with asphalt and for use as an abrasive (sand paper, sand blasting).

6. CONCLUSION

The standard field and laboratory physical, and chemical analysis results have shown that the Effurun River sand at Ugbolokposo and Ugbomro can primarily be used in the glassmaking, building and construction industries. It can also be used in sanitaryware making such as washing sinks and baths; low quality glass types such as common window glass and pyrex. The sand can be processed by washing, floatation, mechanical separation and chemical treatment to improve the quality of sand for use in colourless glassmaking.

7. REFERENCES

- Allen, J. R. L., 1965. Late Quaternary Niger Delta and adjacent areas: Sedimentary environment and lithofacies Bull. A.A.P.G. 49, pp. 547-600.
- Arumala, J. O. and Akpokodje, E. G., 1987. Soil properties and pavement performance in the Niger Delta. Quarterly Journal of Engineering Geology, London. Vol. 20, pp. 287-296.
- Burke, K. and Durotoye, B., 1970b. The Quaternary in Nigeria: A review Bull. ASEQUA vol. 25, pp.79-96. British Standard: BS 2975: 1988
- Collins L. and Fox, R. A.1985. ed. AGGREGATES: SAND, GRAVEL, & CRUSHED ROCK AGGREGATES FOR CONSTRUCTION PURPOSES. Geological Society Engineering Geology Special Publication.
- Durotoye, B., 1976. Quaternary sediments in Nigeria. In: Geology of Nigeria (C. A. Kogbe Ed.) Elizabethan Press, Lagos, pp.431-444.
- Doust, H. and Omatsola, E.,1989. The Niger Delta. AAPG Memoir 48, pp.201-238
- Egirani, D. E. and Obande, O. D. (2003).Utilization of Makurdi River sand for sanitaryware and glass making, Intergrated Journal of Environment, Science & Technology, 34, 2810-2814)
- Glass Making Raw Materials: Sand. Reference:48/340, 1974).
- Gutt, W., 1972. Aggregates for waste materials. Building Research Station Current Paper, 14/72
- Gutt, W. and Nurse, R. W., 1974. The phase composition of Portland cement clinker. Current paper 96/74, Building. Research. Establishment, Watford, U. K.
- Hamascch, C. R. 1991. Britiah glass, 14
- Knill, J. K., 1978. Industrial Geology, ed. Oxford University Press, 344p.
- Leibe, F., 1999, Millers' glass of the 20's and 30's, a collector's guide, 5-10
- Murat, B., 1970. Stratigraphy and paleography of the Cretaceous and Lower Tertiary in Southern Nigeria. In: T.F.G. Dessauvagie and A. J. Whiteman (Eds.) African Geology. Geology Department, University of Ibadan, pp. 251-266.
- Okeke, C. O. and Okogbue, C. O., 2010. Distribution and geotechnical properties of expansive soils in parts of southern Nigeria. Journal of Mining and Geology,46(1), pp. 13-31
- Okonny, I.P., 1999. Geology and soils. In: Alagoa, E. J.(Ed.). Land and People of Bayelsa State: Central Niger Delta. Onyoma Publications, Port Harcourt, pp.9-30.
- Pettijohn, F.J., 1957. Sedimentary rocks, 2nd ed. Harper, New York,. 718p.
- Reyment, R. A.1967., Aspects of the Geology of Nigeria. Ibadan University Press, Ibadan, Nigeria.
- Short, K. C. and Stauble, A. J., (1976). Outline of the Geology of the Niger Delta, Bull. American. Association of Petroleum. Geology. 51, pp. 761-779.
- Slack, R., 1987, English pressed glass, 1830-1900.
- Tse, A. C. and Akpokodje, E. G., 2010. Subsurface soil profiles in site investigation for foundation purposes in parts of the mangrove swamps of the eastern Niger Delta. Journal of Mining and Geology, 46(1), pp. 79-91
- Thompson, J., 1989, the identification of English pressed glass, 10-15
- Tucker, M. E., 1981. Sedimentary Petrology An Introduction. Blackwell Scientific Publications, 252p.
- Udden, J.A., 1914. Mechanical composition of clastic sediments. Geoological Society of America Bull., Vol. 25, pp655-744.

- Weber, K., 1971. Sedimentological aspects of oilfields in the Niger Delta. Geol. En Mijnbouw. Vol. 50, pp. 559-576.
- WentWorth, C.K., 1922. A scale of grade and class terms for clastic sediments, Jour. Geology 30, pp.377-392.
- Wessey, N., 1984.The Nuckwood, Rockford sand deposit as a glassmaking raw material. M.Sc. thesis, University of Hull, Hull, 120p.
- Wessey, N., 1988.The evaluation of the industrial potential of Nigerian direct reduction steelmaking slag. Ph. D. thesis, University of Hull, Hull, 316p.